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$$x^4 - (a^2 + b^2 + 2c^2)x^2 + 4abcx - c^2(a^2 + b^2 - c^2) = 0 \dots \dots \dots (5).$$

Restoring numbers in (5), we have

$$x^4 - 2518x^2 + 14400x - 22419 = 0.$$

Solving this equation by Horner's Method, we find  $x = 47.145$  feet, nearly.



## CALCULUS.

Conducted by J. M. COLAW, Monterey, Virginia. All contributions to this department should be sent to him.

## SOLUTIONS OF PROBLEMS.

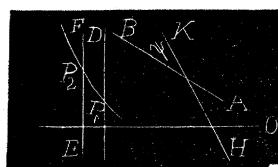
58. Proposed by O. W. ANTHONY, M. Sc., Professor of Mathematics, Columbian University, Washington, D. C.

A line passes through a fixed point and rotates uniformly about this point. Another line passes through a point which moves uniformly along the arc of a given curve and rotates uniformly about this point. Develop a method for finding the locus of intersection of these two lines. Apply to case of circle and straight line.

II. Solution by C. W. M. BLACK, A. M., Professor of Mathematics in Wesleyan Academy, Wilbraham, Massachusetts.

Let  $O$  be the origin,  $P_3$  the fixed point, its coördinates being  $(r_3, \theta_3)$ , and let  $AB$  be a given position of line through  $P_3$ . Let  $P_1(r_1, \theta_1)$  be position of point on curve and  $CD$  the line through it, both corresponding to the position  $AB$  of other line. Also let  $HK$  be position of  $AB$  revolved through an  $\angle \psi$ , and let  $P_2(r_2, \theta_2)$  and  $EF$  be the corresponding position of  $P_1$  and  $CD$ .

Let  $r = f(\theta)$  be equation to curve  $P_1P_2$ . Let  $\eta$  = the angle made by  $AB$ , and  $\eta_1$  the one made by  $CD$  with a polar axis. Let  $a$  = angular rate of revolution of  $AB$ , and  $na$  of  $CD$ .



$\therefore$   $\angle$  between  $CD$  and  $EF = n\psi$ .

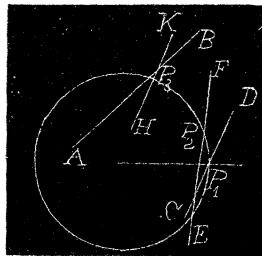
Let  $b$  = linear rate of movement of  $P_1$ . Then  $\psi/a = P_1P_2/b \dots \dots \dots (1)$ .

Equation to  $HK$  is  $r = [r_3 \sin(\eta + \psi - \theta_3)] / \sin(\eta + \psi - \theta) \dots \dots \dots (2)$ .

Equation to  $EF$  is  $r = (r_2 \sin(\eta_1 + n\psi - \theta_2)) / \sin(\eta_1 + n\psi - \theta) \dots \dots \dots (3)$ .

By integration,

which gives  $P_1 P_2$  in terms of  $\theta_2$ ,  $\theta_1$  being known. Then substitute from (4) in (1) to get  $\psi$  in terms of  $\theta_2$ . Substitute this value, and also  $f(\theta_2)$  for  $r_2$  in (2) and (3). Then by eliminating  $(\theta_2)$  we have resulting the equation to the locus of the intersecting of the lines. The solution depends on our ability to integrate (4). Now if the given lines are not straight, it is evident that the only changes are in equations (2) and (3). These may be derived from the equations to the lines in original position by a method of transformation of coördinates. For example, the equation to  $HK$  may be derived from that to  $AB$  by revolving the pole and polar axis about  $P_3$  through an angle equal to  $\psi$  and in the opposite direction. If the given curve is a circle and the lines straight, the problem can be definitely solved as follows :



Transform coöordinates so that center of circle shall be pole and  $OP_1$  the the polar axis. Then  $r=f(\theta)$  becomes  $r=c$ .

Let  $(r_1, \theta_1)(r_2, \theta_2)(r_3, \theta_3)$  represent the new coördinates of points  $P_1, P_2, P_3$ , respectively.

Then  $r_1 = r_2 = c$ ,  $\theta_1 = 0$ ,  $P_1 P_2 = c\theta_2$ . From (1)  $\psi = ac\theta_2/b$ .

(5) can be solved for  $\theta_2$  and the result can be substituted in (6), giving the equation required. Then if desired the coördinates can be again transformed to the original form.

## MECHANICS.

Conducted by B. F. FINKEL, Springfield, Mo. All contributions to this department should be sent to him.

## SOLUTIONS OF PROBLEMS.

43. Proposed by B. F. FINKEL, A. M., M. Sc., Professor of Mathematics and Physics in Drury College, Springfield, Missouri.

Two weights  $P$  and  $Q$  rest on the concave side of a parabola whose axis is horizontal, and are connected by a string, length  $l$ , which passes over a smooth peg at the focus,  $F$ . [Bowser's *Analytical Mechanics*, page 54.]